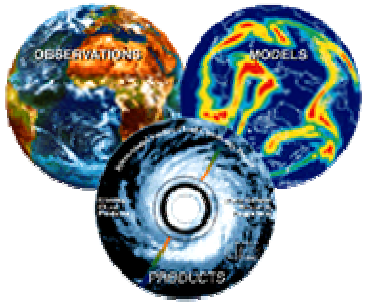
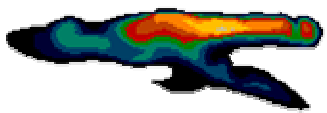
Cirrus Parcel Model Comparison **Project** Phase 2



GEWEX
WCRP



GEWEX Cloud Systems Studies

Working Group II: Cirrus Cloud Systems

Ruei-Fong Lin **(L)**
UMBC/GEST, Baltimore, MD, USA

David O'C. Starr
Laboratory of Atmosphere, NASA/GSFC, Greenbelt, MD, USA

Paul J. DeMott **(D)**
Dept. of Atmospheric Sciences, CSU, Fort Collins, CO, USA

Richard Cotton **(C)**
Meteorological Flight, Hants, UK

Eric Jensen **(J)**
NASA/Ames Research Center, Moffett Field, CA, USA

Bernd Kärcher **(K)**
DLR Oberphaffenhofen, Institut für Physik der Atmosphäre, Wessling, Germany

Xiaohong Liu **(X)**
Dept. of Atmospheric, Oceanic, and Space Sciences, Univ. of Michigan, MI, USA

Cirrus Initiation:
Nucleation Mode:
Homogeneous nucleation of H_2SO_4 haze particles

J = J(T, wt%)

Phase 1
(JAS, 2002, 59, 2305-2329)

PHASE 2

Motivation

* To study the effects of background aerosol size distributions and properties on the predicted cirrus microphysical properties.
* To understand the differences in model responses to the change of background aerosols.

CPMC-P2 Simulation Protocol

The background aerosol distributions: log-normal.

CTRL

Sensitivity tests:

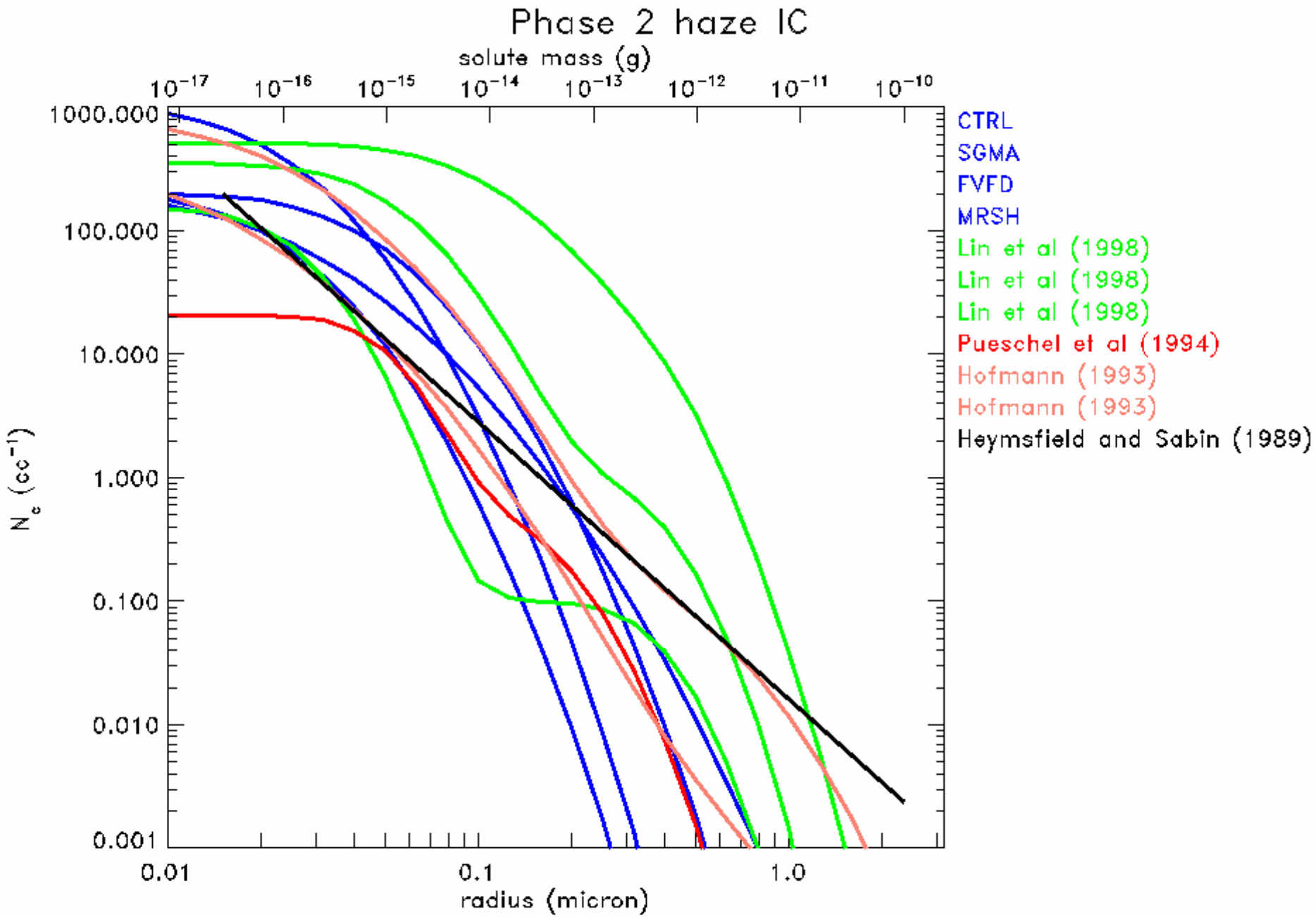
- **Chang in the total aerosol number concentration**
- **Chang in the mode radius**
- **Chang in the spectrum width**
- **Chang in the parameter λ**

Two initial temperatures: -40ºC (warm) and -60 ºC (cold)

Three updraft speed: 0.04, 0.2, 1 m s^{-1}

The deposition coefficient = 0.5

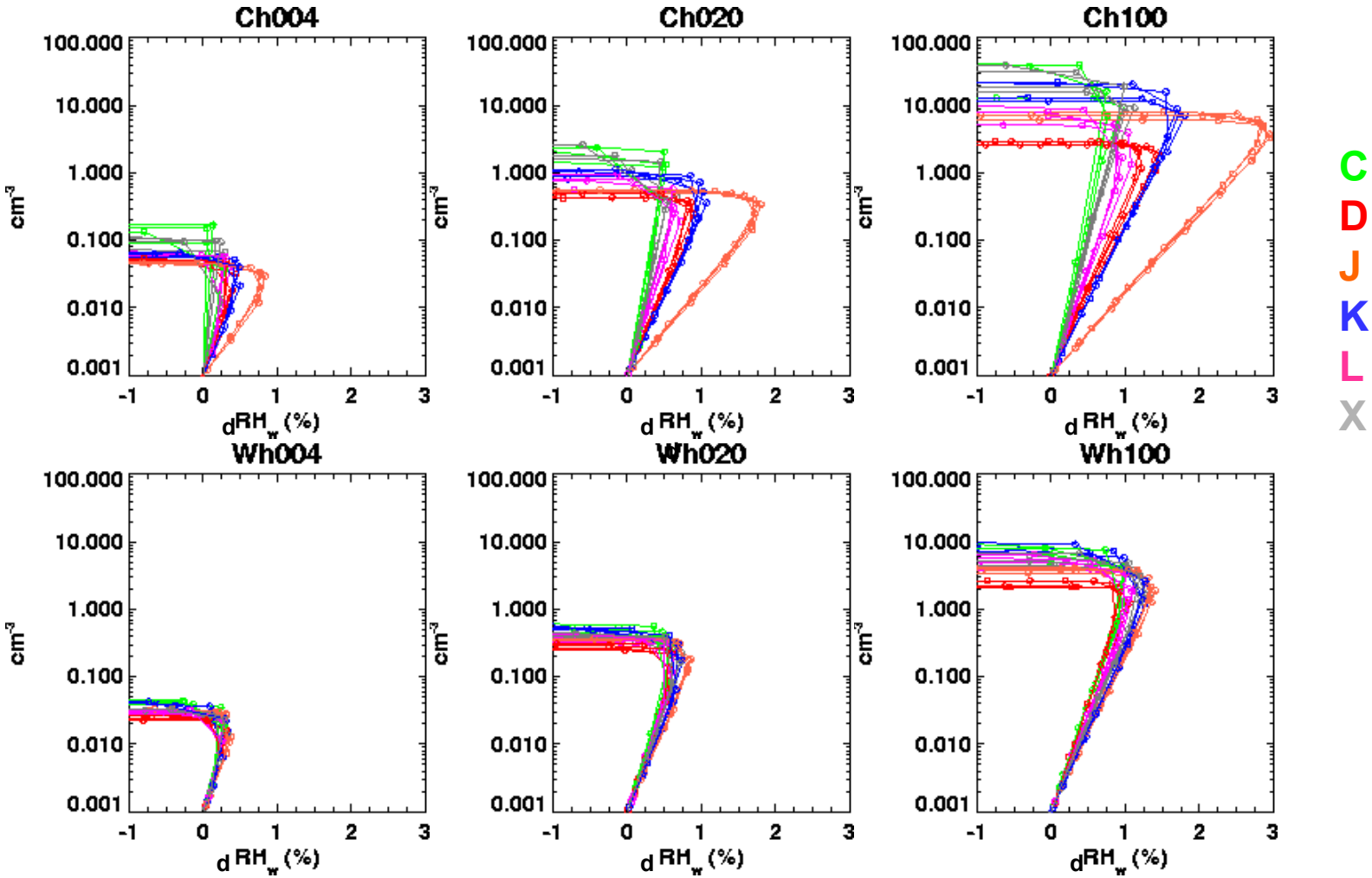
The condensation coefficient = 0.06



Cumulative haze particle distributions

$$N_c(r) = \int_r^\infty N(r)dr$$

Number concentration of freezing haze particles as a function of dRH_w



Inter-model differences ≥ aerosol effect (at least for the range of variation in the aerosol distributions studied here)

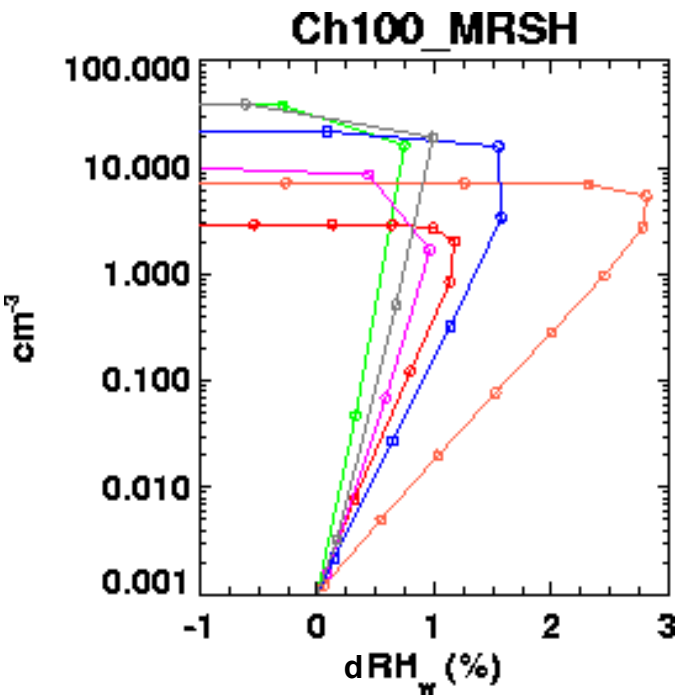
The predicted ice particle number concentration
Summary of Phase 1 and 2

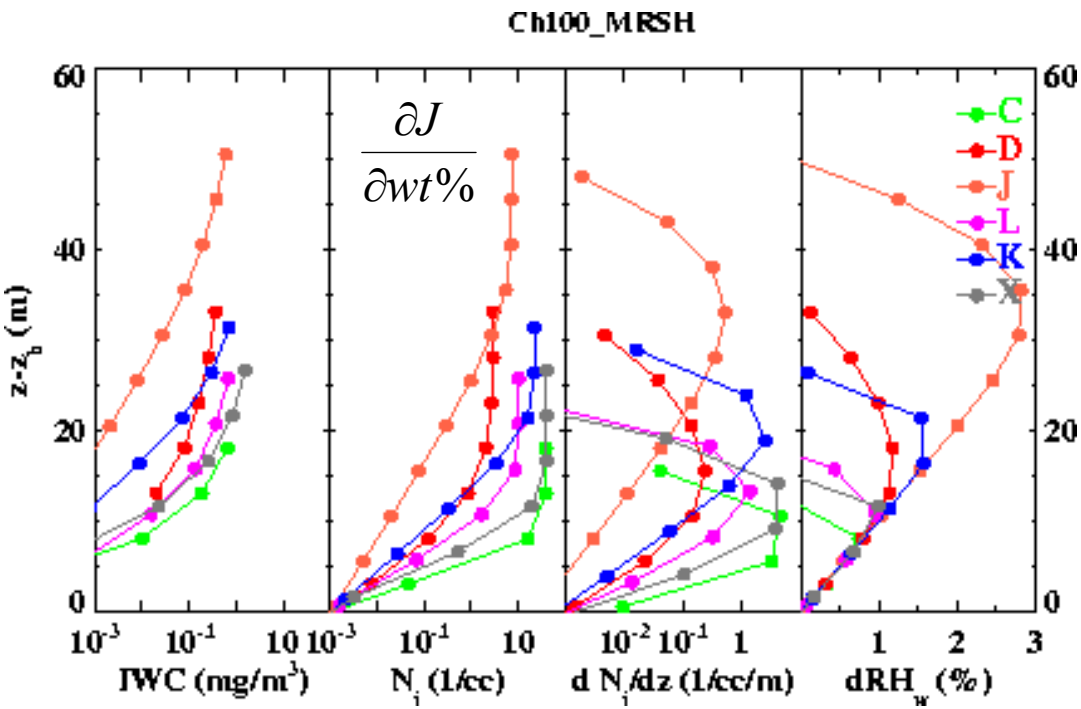
Updraft speed (0.04-1.0 m s^{-1})	**~a factor of 100 or more**
Temperature (-40°C to -60°C)	**~a factor of 10 or less (updraft speed dependent)**
Deposition coefficient (0.06 – 1.0)	**~a factor of 4~5 (-40°C)** **~a factor of 9~12 (-60°C)**
Inter-model differences	**~a factor of 1~3 (-40°C; -60°C, weak updraft)** **~a factor of 4~13 (-60°C, moderate-fast updraft)**
Aerosol effect	**~a factor of 2 (the most responsive model)**

Why the inter-model differences are big in Ch100_MRSH case?

Nucleation regime ($dN_i / dz > 0$)

In-cloud height: $z-z_b$





Gap between the smallest ice particle bin and the actual sizes of freezing haze particles

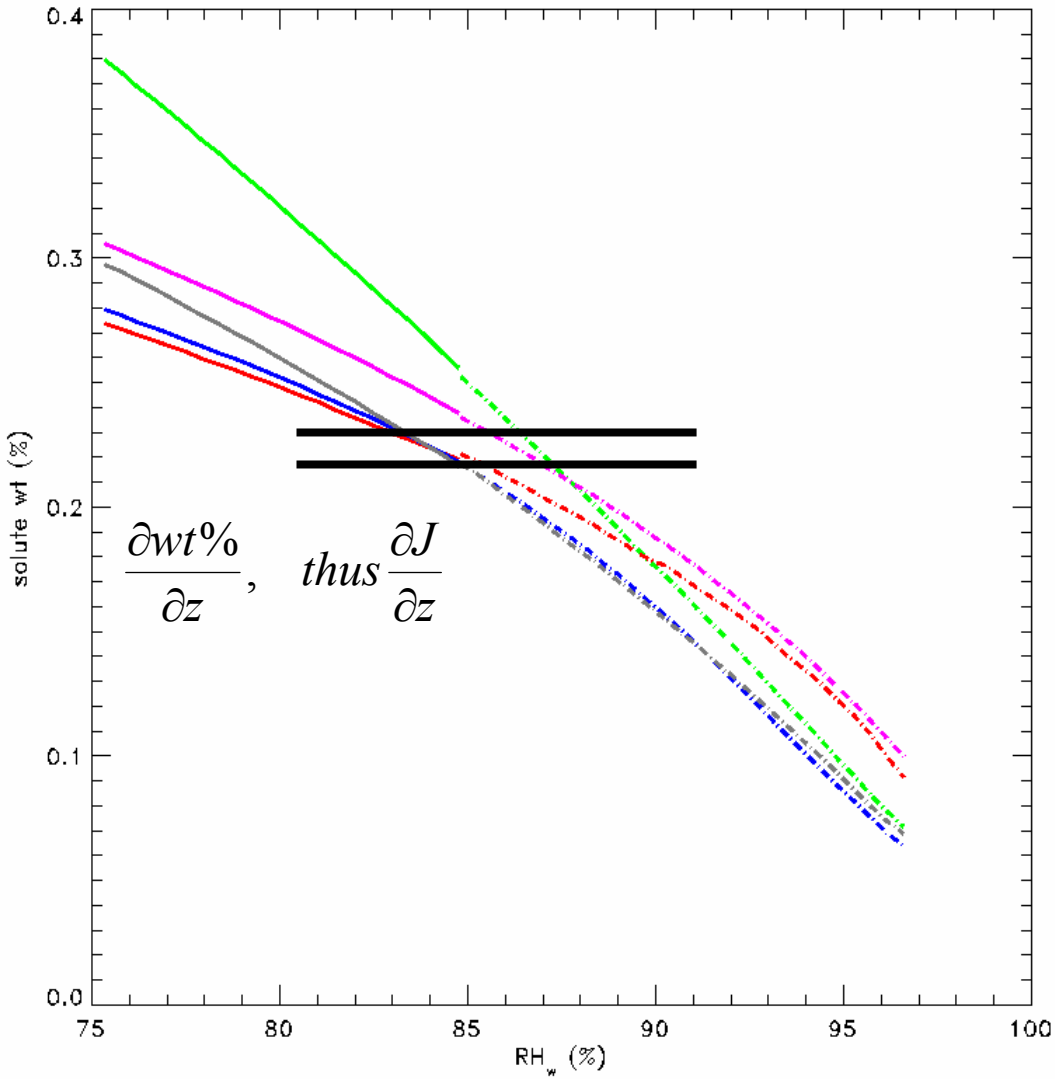
Model L: Ni (no gap)/Ni (with gap)

	CTRL	FVFD	MRSH	SGMA
Ch004	1.03	1.06	1.05	1.03
Ch020	**1.21**	**1.27**	**1.24**	**1.17**
Ch100	**1.73**	**2.12**	**1.91**	**1.60**
Wh004	1.01	1.01	1.00	1.00
Wh020	1.03	1.03	1.02	1.01
Wh100	1.11	1.14	1.11	1.08

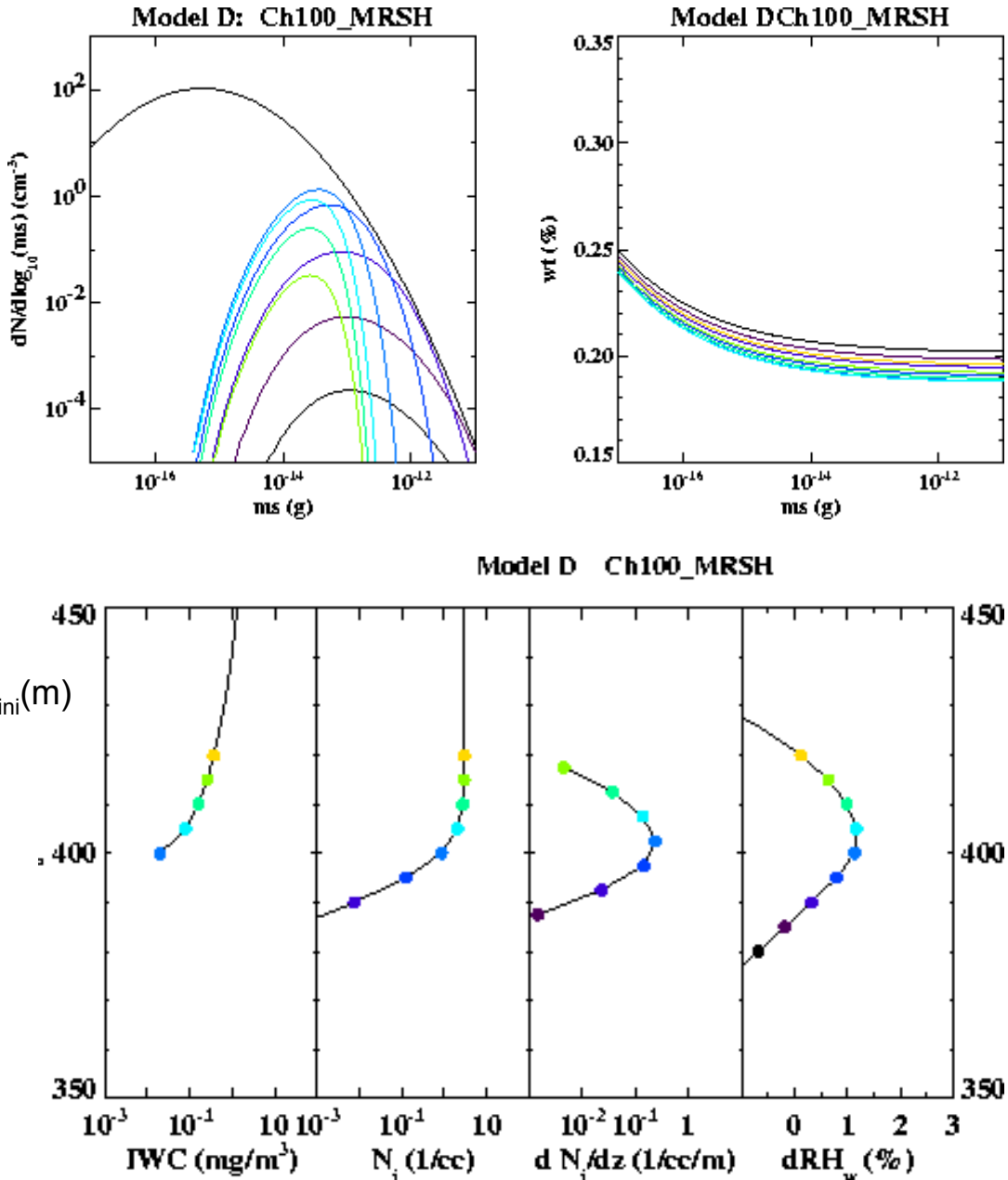
The solute wt% of an equilibrium-sized haze particle (ms = 10^{-14} g)

The gradient of equilibrium wt% with respect to humidity

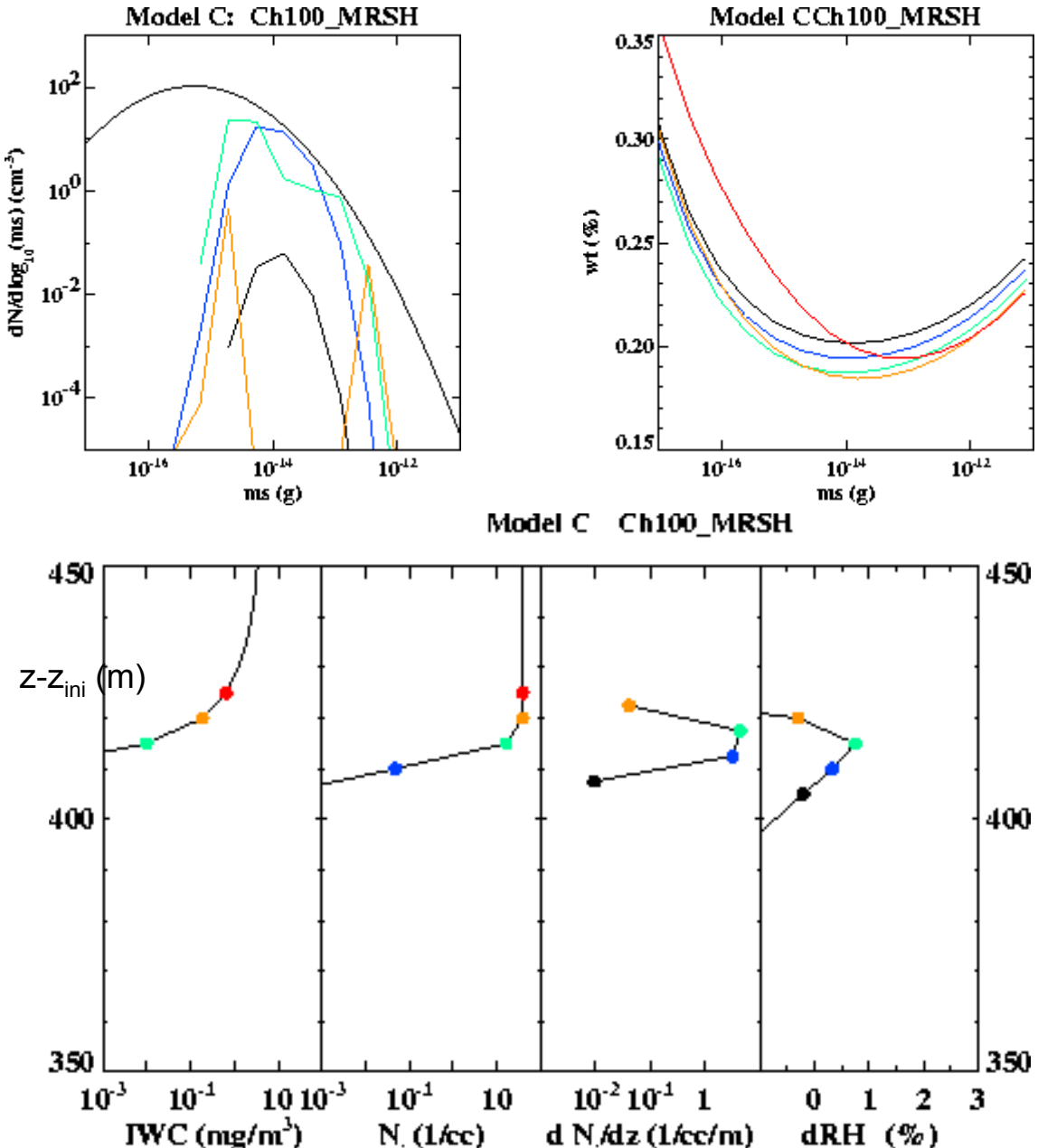
(a) Kelvin's effect
(b) Water activity
(c) Solution density



Assumption: haze particles are in equilibrium with the environment



Diffusional growth of haze particles are explicitly calculated



Summary

Inter-model differences of Phase 2 were reduced compared to Phase 1.

Inter-model differences were still significant in some cases, particularly for cold and fast updraft.

For the sensitivity tests performed, the change in the background aerosol particle size distribution is secondary compared to updraft, temperature, deposition coefficient, and inter-model difference.